Assessment of Suomi NPP VIIRS Vegetation Index EDR

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Introduction

The Visible Infrared Imaging Radiometer Suite (VIIRS) Vegetation Index (VI) Environmental Data Record (EDR) includes the Top of the Atmosphere (TOA) Normalized Difference Vegetation Index (NDVI) and the Top of the Canopy (TOC) Enhanced Vegetation Index (EVI). The VI EDR is an operational product generated by the Interface Data Processing Segment (IDPS) of the Suomi National Polar-orbiting Partnership (S-NPP) ground segment. In this work, we present the results of our quality assessment of the VI EDR product after launch via product inter-comparison to Aqua MODIS and NOAA-18 AVHRR/3 (not shown in this poster). In general, the early VIIRS VI EDR product showed good product integrity and was found radiometrically performing well, while the product still contained some temporal, geographic, and target brightness-dependent biases, and residual contaminations. The VI EDR was promoted to beta maturity status in February 2013, and it is now available to the general public through NOAA's Comprehensive Large Array-Data Stewardship System (CLASS). A series of improvements to the VI EDR product including enhancing the Quality Flags (QF) were proposed and are in the implementation phase. A more comprehensive set of QFs is necessary to allow users to better screen suspicious quality pixels that cannot be screened by the current set of VI-EDR QFs. The additional QFs include: snow/ice, cloud shadows, cloud adjacency, and aerosol quantity. The ongoing validation efforts and product improvements will lead to the VI EDR reaching provisional maturity status in the near term.

Vegetation Index EDR Product Description

- The Vegetation Index EDR provides the Normalized Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI), and per-pixel quality flags (QFs) at 375 m (Imagery resolution) on a daily, global basis.
  - The NDVI derived from "Top-of-the-Atmosphere (TOA)" I1 and I2 reflectance

$$NDVI = (\rho_{I2}^{TOA} - \rho_{I1}^{TOA})/(\rho_{I2}^{TOA} + \rho_{I1}^{TOA})$$

  - The EVI derived from "Top-of-Canopy (TOC)" I1 and I2, and M3 reflectance

$$EVI = (1+L)\cdot\frac{\rho_{I2}^{TOC} - \rho_{I1}^{TOC}}{\rho_{I2}^{TOC} + C_1\cdot\rho_{I1}^{TOC} - C_2\cdot\rho_{M3}^{TOC} + L}$$

  - QFs including: (1) Land/Water Mask, (2) Cloud Confidence, (3) Thin Cirrus, (4) Heavy Aerosol Loading, and (5) Day/Night Flag
- **Additional Quality Flags for VI-EDR**: Additional quality flags are desirable for VI EDR in order to screen suspicious quality pixels that cannot be screened by the current set of VI-EDR QFs. The following QFs will be operationally implemented in IDPS build Mx8.4 (May 2014)
  - Adjacency clouds (yes or no)
  - Cloud shadows (yes or no)
  - Snow/ice (yes or no)
  - Aerosol quantity (climatology, low, average, high)
- **Current Challenges**:
  - The VIIRS NDVI which is derived from TOA reflectance is inherently different from the MODIS NDVI which is derived from TOC reflectance.
  - The VIIRS EVI equation uses a different gain factor from that used in the MODIS equation, requiring an adjustment for compatibility.
  - VI EDR is provided in swath/granule form which is neither geographically projected nor temporally composited.

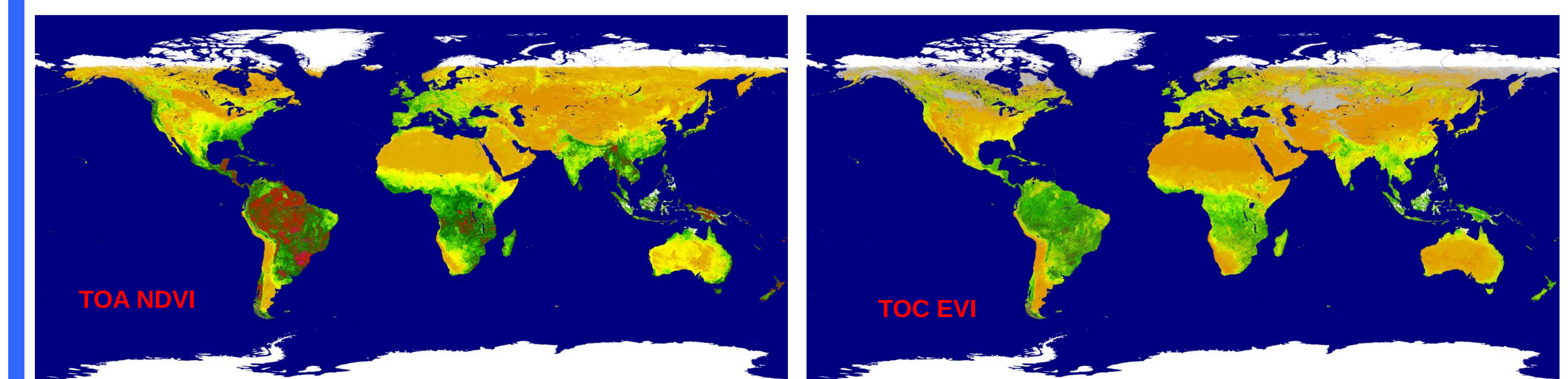
Spectral bands of polar imagers

Spectral bands of polar imagers (nm or um)

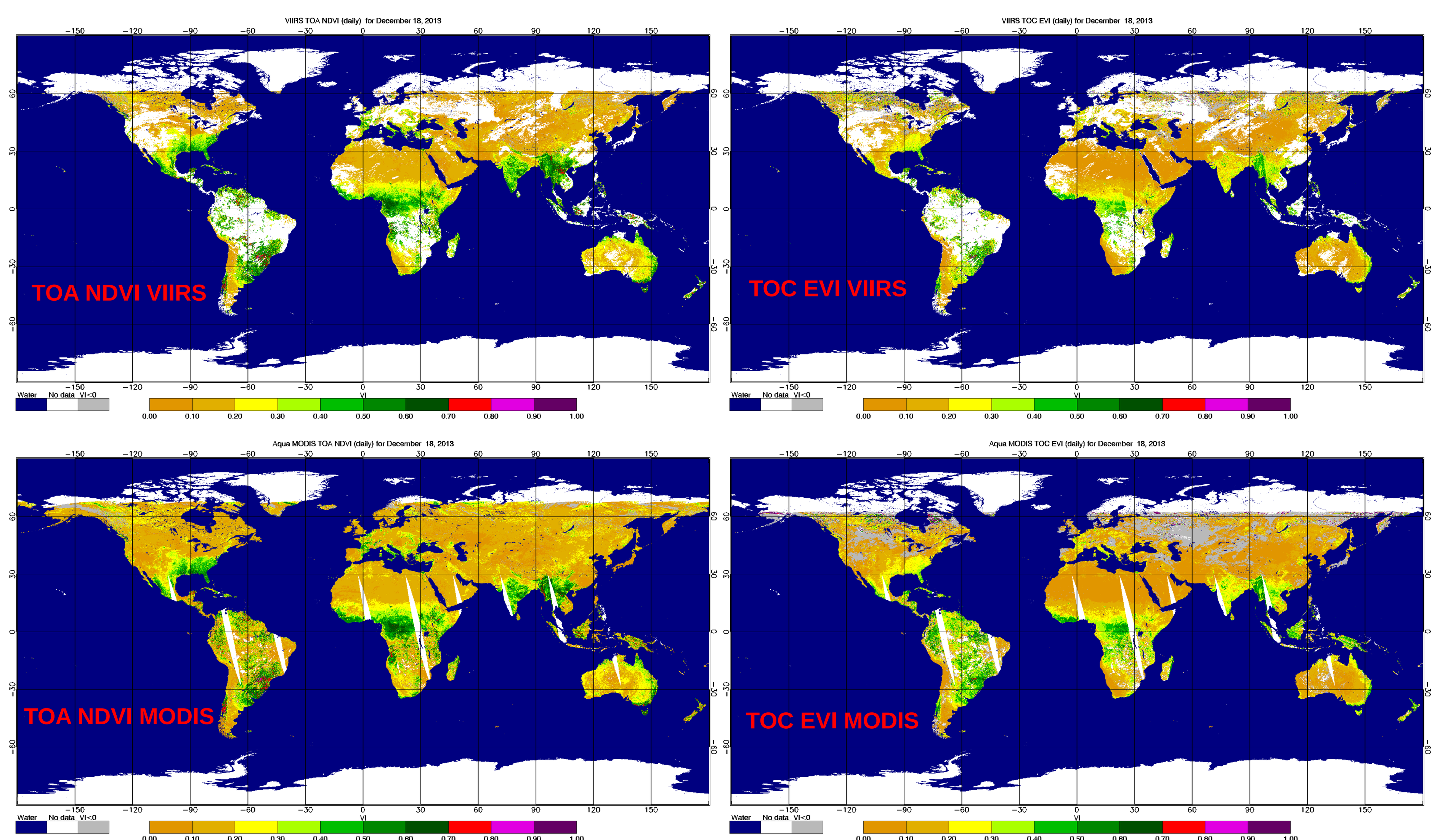
AVHRR		MODIS		VIIRS	
1	580 – 680	8	405 - 420	M1	402 – 422 (750m)
2	840 – 940	9	438 - 448	M2	436 - 464
3a	1.58-1.64	10	483 - 493	M3*	478 - 498
3b	3.55 - 3.93	12	546 - 556	M4	545 - 565
4	10.3 - 11.3	1	620 - 670	I1*	580 – 680 (375m)
5	11.5 - 12.5	13	662 - 672	M5	662 - 682
		15	743 - 753	M6	744 - 758
		16	862 - 877	M7	845 - 885
		2	841 - 877	I2*	845 - 885
		5	1.23 - 1.25	M8	1.23 - 1.25
		26	1.36 - 1.39	M9	1.371 - 1.385
		6	1.63 - 1.65	M10	1.58 - 1.64
		7	2.11 - 2.16	I3	1.58 - 1.64
		20	3.66 - 3.84	M11	2.235 - 2.285
		23	4.02 - 4.08	M12	3.61 - 3.79
		29	8.40 - 8.70	I4	3.55 - 3.93
		31	10.78 - 11.28	M13	3.97 - 4.13
		32	11.77 - 12.27	M14	8.40 - 8.7
		33	13.2 – 13.5	M15	10.3 - 11.3
		34	13.5 – 13.8	M16	11.5 - 12.5
		35	13.8 – 14.1	I5	10.6 - 12.5
		36	14.1 – 14.4		

* VIIRS bands used by the VI-EDR Algorithm

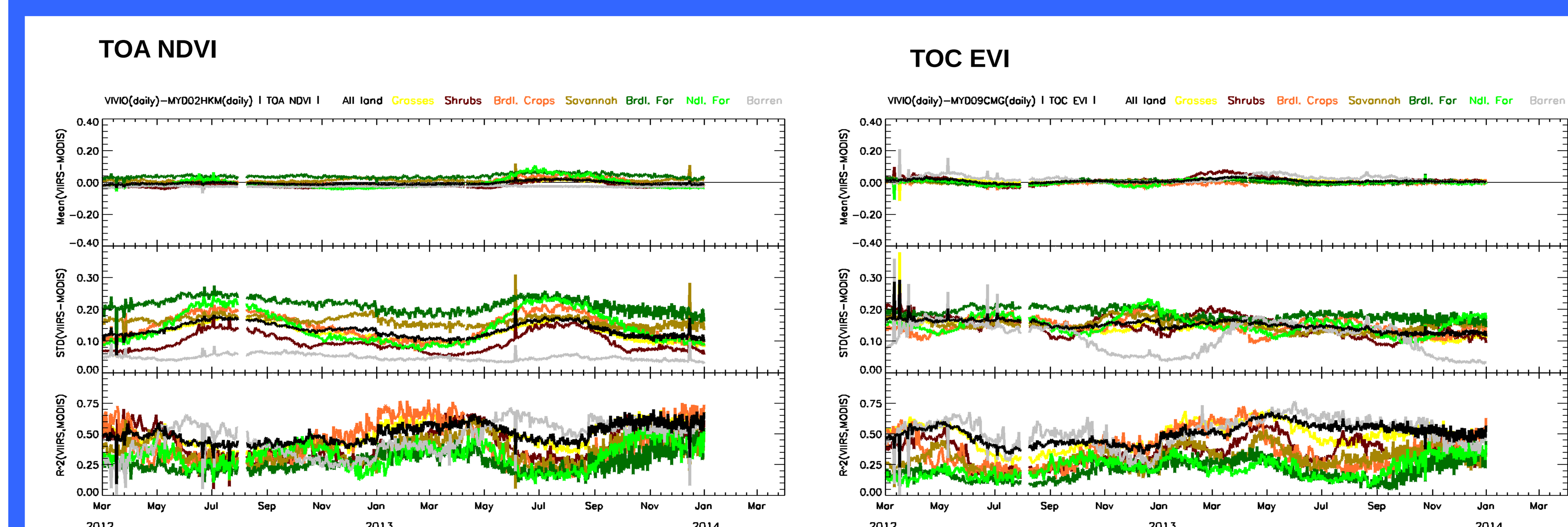
VIIRS VI-EDR Global 16-Day Composites (January 9-24, 2014)



Daily VIIRS vs. MODIS VI Product December 18, 2013

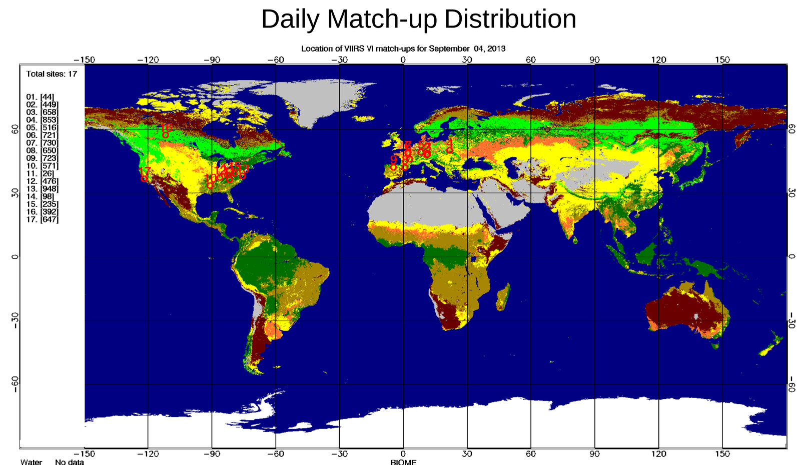


VI-EDR Time Series



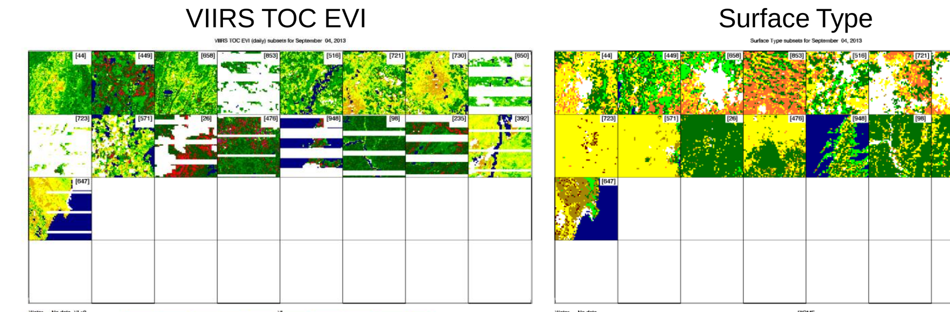
Match-up Analysis

Daily Match-up Distribution

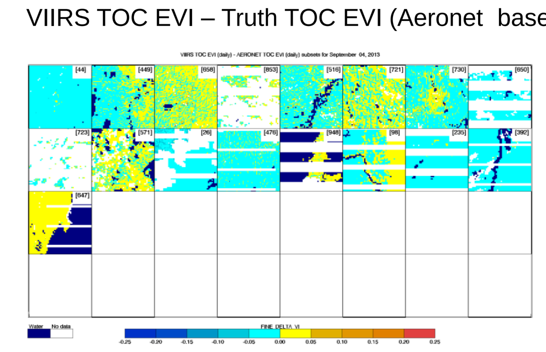


VIIRS TOC EVI

Surface Type



VIIRS TOC EVI – Truth TOC EVI (Aeronet based)



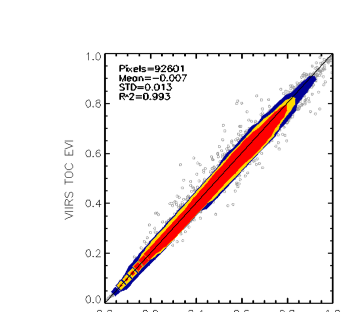
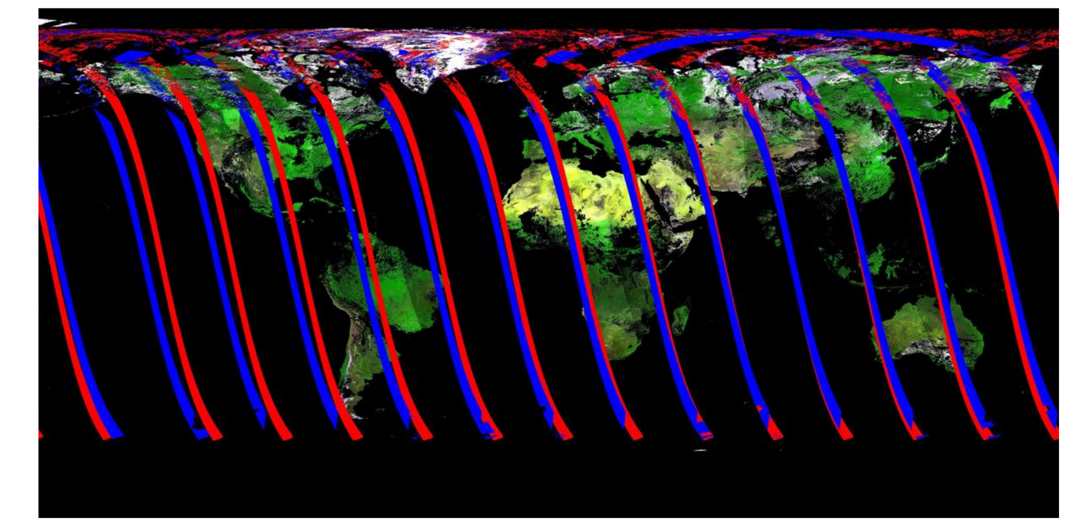


Table 1. Summary statistics VIIRS SR and Match-up tool SR (Aeronet based)

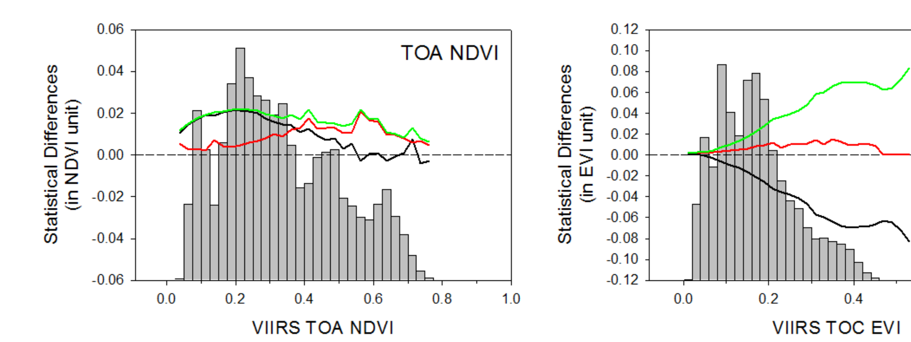
	mean	STD	R^2
TOC Red	-0.0129	0.0198	0.9761
TOC Blue	-0.0114	0.0176	0.9227
TOC NIR	-0.0152	0.0214	0.9604
TOC EVI	-0.0044	0.0184	0.9812
TOC NDVI	0.0058	0.1138	0.9815

Near-simultaneous nadir observations. Global mosaic comparisons with Aqua MODIS

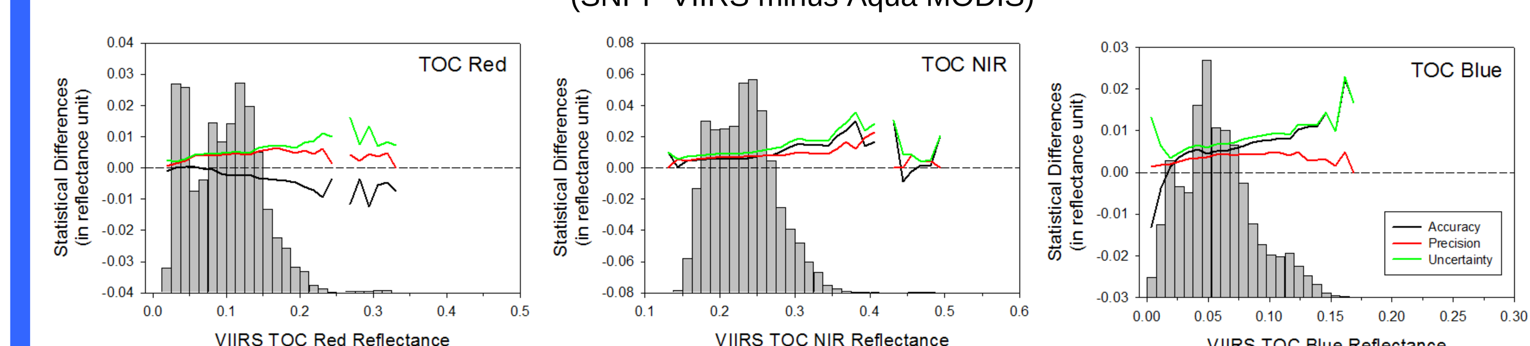


Near-simultaneous nadir observations Overlapped orbital tracks with view zenith angles < ±7.5 degrees over a 16 day period. Solar zenith angle differences of 1-2 degrees Blue: NPP VIIRS Red: Aqua MODIS

VIIRS Vegetation Index APU Metrics: 2013 261-266 (SNPP VIIRS minus Aqua MODIS)



VIIRS Input Reflectance APU Metrics: 2013 261-266 (SNPP VIIRS minus Aqua MODIS)



VI-EDR Dependency on other SDRs/IPs

Algorithm	Beta	Provisional	Val 1	Val 2	Val 3
Vegetation Index	Feb-13	Jan -14*	July-14	Jan-15	Jan-16
SDR	Apr-12	Mar -13	Dec -13		
Surface Reflectance RIP	Feb-13	Oct -13	July -14	Jan-15	Jan-16
Cloud Mask	Oct -12	Feb -13	Jan -14	Jun-14	Mar -15

*Conditionally approved

Summary

- This analysis is based on data from VIIRS, MODIS and AERONET.
- MODIS 8-biome land cover mask was used to quantify variations in VI product performance as function of surface type.
- Cal/Val activities include:
  - ➢ Evaluation of VIIRS VI-EDR using MODIS and AVHRR(not shown in this poster) VI products
  - ➢ Evaluation and validation of VIIRS VI-EDR using the AERONET-based Surface Reflectance Validation Network (ASRVN) data stream at a limited number of sites.
  - ➢Evaluation and validation of VIIRS VI EDR using tower-based reflectance networks, Including PEN, BSRN, and FLUXNET (not shown in this poster), Cross-sensor compatibility analysis among VIIRS, AVHRR, and MODIS for the NDVI, EVI, and EVI2
- Differences between VIIRS-EVI and MODIS-EVI are caused by: different gain factor (VIIRS = 2 and MODIS = 2.5) and differences in the spectral response functions, specially the blue band.
- The Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on Suomi NPP has been successfully collecting satellite data that is regularly used by our customers, the weather forecasting and science communities, as a critical weather prediction tool. VIIRS provides valuable data for accurately monitoring global and long-term weather patterns.
- The Joint Polar Satellite System (JPSS) is committed to the successful operation of the Suomi NPP satellite launched in 2011, the successful and timely launch of the next polar weather satellite JPSS-1 (2017), as well as the development and launch of the subsequent polar-orbiting weather satellite, known as JPSS-2 (2022).

Acknowledgements and Disclaimer

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